Hydro-DO Manual

Digital Optical Dissolved Oxygen Sensor

Sea-Bird Coastal
13431 NE 20th Street
Bellevue, WA 98005

+1 425-401-7654
support@sea-birdcoastal.com
www.sea-birdcoastal.com

Manual Version 007, 12/10/13
Firmware Version 3.1.0
SeatermV2 Version 2.3.0 and later
SBE Data Processing Version 7.23.1 and later

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Declaration of Conformity

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005 USA

DECLARATION OF CONFORMITY

Manufacturer's Name: **Sea-Bird Electronics**
Manufacturer's Address: 13431 NE 20th Street
Bellevue, WA 98005, USA

The Authorized Representative located within the Community is:
OTT MESSTECHNIK GmbH & Co.KG
P.O.Box: 2140 / 87411 Kempten / Germany
Ludwigstrasse 16 / 87437 Kempten
Internet: http://www.ott.com
Phone: +49 831 5617 – 100
Fax: +49 831 5617 - 209

Device Description: Various Data Acquisition Devices and Sensors

Model Numbers:

3S	3F	3plus	4C	4M	5T	5P	5M	7
8	9plus	11plus	14	16plus V2	16plus-IM V2		17plus V2	18
19plus V2	21	25plus	26plus	27	29	32	32C	32SC
33	35	35RT	36	37-IMP	37-IM	37-SMP	37-SM	37-SIP
37-SI	38	39	39-IM	39plus	41	41CP	43	43F
44	45	49	50	52-MP	53BPR	54	55	56
63	SIM	ICC	IMM	PDIM	AFM	90488	90204	90402
90504	Glider Payload CTD		NiMH Battery Charger and Battery Pack					

Applicable EU Directives:
Machinery Directive 98 / 37 /EC
EMC Directive 2004 / 108 /EC
Low Voltage Directive (73 / 23 /EEC) as amended by (93 / 68 /EEC)

Applicable Harmonized Standards:
EN 61326-1:2006 Class A Electrical Equipment for Measurement, Control, and Laboratory Use, EMC Requirement – Part 1: General Requirements
(EN 55011:2007 Group 1, Class A)

EN 61010-1:2001, Safety Requirements for Electrical Equipments for Measurement, Control, and Laboratory Use – Part 1: General Requirements

Declaration based upon compliance to the Essential Requirements and Letter of Opinion from CKC Certification Services, LLC., Notified Body 0976

I, the undersigned, hereby declare that the equipment specified above conforms to the above European Union Directives and Standards.

Authorized Signature:
Name: Nordeen Larson
Title of Signatory: President
Date: 3 September 2013
Place: Bellevue, WA

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Section 1: Introduction

This section includes a Quick Start procedure, and photos of a standard Hydro-DO shipment.

About this Manual

This manual is to be used with the Hydro-DO Digital Optical Dissolved Oxygen Sensor. It is organized to guide the user from installation through operation and data collection. We've included detailed specifications, command descriptions, maintenance and calibration information, and helpful notes throughout the manual.

Sea-Bird welcomes suggestions for new features and enhancements of our products and/or documentation. Please contact us with any comments or suggestions (support@sea-birdcoastal.com or +1 425-401-7654). Our business hours are Monday through Friday, 0800 to 1700 Pacific Standard Time (1600 to 0100 Universal Time) in winter and 0800 to 1700 Pacific Daylight Time (1630 to 0000 Universal Time) the rest of the year.

Quick Start

Follow these steps to get a Quick Start using the Hydro-DO.
The manual provides step-by-step details for performing each task:

1. Perform pre-check procedures (see *Section 3: Preparing Hydro-DO for Deployment*):
   A. Test power and communications.

2. Deploy the Hydro-DO (see *Section 4: Deploying and Operating Hydro-DO)*:
   A. Establish setup and operating parameters.
   B. Check status (**GetSD**) and calibration coefficients (**GetCC**) to verify setup.
   C. Install I/O cable connector and locking sleeve, and mount Hydro-DO.
   D. Deploy Hydro-DO.

Unpacking Hydro-DO

Shown below is a typical Hydro-DO shipment.

Hydro-DO

Optional sensor mount for installation on SBE 19*plus* V2

Software, and Electronic Copies of Software Manuals and User Manual

Section 2: Description of Hydro-DO

This section describes the functions and features of the Hydro-DO, including specifications and dimensions.

System Description

Hydro-DO

The Hydro-DO is an easy-to-use, light, compact instrument ruggedly made of titanium and other low-maintenance (plastic) materials, designed to be incorporated into oceanographic sensing systems at depths up to 600 meters (1960 feet). Commands sent to the Hydro-DO provide status display, data acquisition setup, and diagnostic tests. Its data is telemetered by its internal, 3-wire, RS-232C interface. The Hydro-DO has no sample memory or internal batteries.

The Hydro-DO samples in two modes:

- **Autonomous sampling** –The Hydro-DO samples at pre-programmed intervals of 1 to 32,767 seconds. It can be set to average up to 255 measurements per sample, and transmits the averaged data. The Hydro-DO can be programmed to begin autonomous sampling when power is applied or on command.
- **Polled sampling** – On command, the Hydro-DO takes one sample and transmits the data.

The Hydro-DO outputs raw or converted (ASCII engineering units) data in one of a number of formats, for compatibility with existing CTDs.

Each Hydro-DO is calibrated individually in a temperature-controlled bath. Bath temperatures are varied at each of 4 oxygen values, providing a comprehensive 24-point calibration. Two reference sensors in each bath are standardized against Winkler titrations. Response time tests are conducted on each sensor, using gas. Salinity and pressure impacts on sensor response are each checked at two separate points.

The Hydro-DO is designed for use in a CTD's pumped flow path, providing optimum correlation with CTD measurements. The elapsed time between the CTD and associated oxygen measurement is easily quantified, and corrected for in post-processing. The plumbing's black tubing blocks light, reducing in-situ algal growth.

Configuration options:

- With the optional sensor mount, the Hydro-DO can be plugged into the RS-232 auxiliary sensor connector of the SBE 19*plus* V2 SeaCAT CTD.
- The Hydro-DO can be integrated into a HydroCAT.

Notes:
- Help files provide detailed information on the software.
- A separate software manual on CD-ROM contains detailed information on the setup and use of Seasave V7 and SBE Data Processing.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

The Hydro-DO is supplied with a powerful Windows software package, Seasoft V2, which includes:

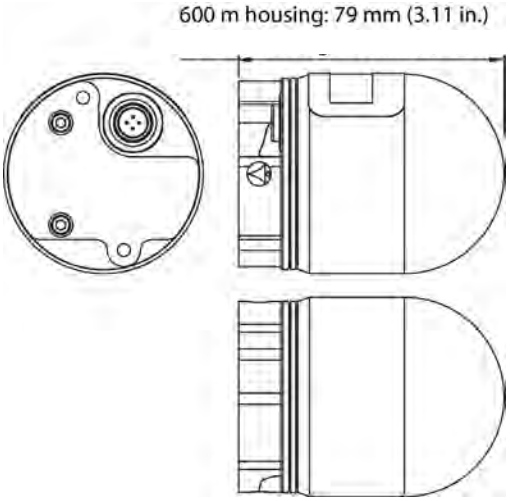
- **SeatermV2** - terminal program for communication and data retrieval. SeatermV2 is a *launcher*, and launches the appropriate terminal program for the selected instrument (**Seaterm232** for RS-232 instruments such as this Hydro-DO).
- **Seasave V7** – program for acquiring, converting, and displaying real-time or archived raw data.
- **SBE Data Processing** – program for calculation and plotting of conductivity, temperature, pressure, auxiliary sensor data (such as dissolved oxygen), and derived variables such as salinity and sound velocity.

Specifications

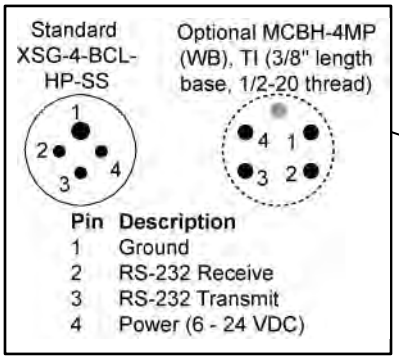
Measurement Range	120% of surface saturation in all natural waters, fresh and salt
Initial Accuracy	Larger of ±3 µmol/kg (equivalent to 0.07 ml/L or 0.1 mg/L) or ±2%
Resolution	0.2 µmol/kg
Sample-Based Drift	< 1 µmol/kg / 100,000 samples (20 °C)
Response Time (τ, 63% response)	< 6 sec (20 °C)
Sampling Speed	1 Hz (1 sample/sec)
Calibration	Each sensor fully and individually calibrated (0 – 450 µmol/kg oxygen, 0 – 30 °C, 0 – 35 psu, 0 – 2000 dbars) 8 coefficients plus 4 temperature compensation coefficients
Input Power	6 - 24 VDC, 35 mA (0.08 J/sample)
Output Signal	RS-232, 600-115,200 baud (user-selectable), 8 data bits, no parity, 1 stop.
Depth rating, housing, and weight (in air)	*Sensor:* 600 m (1960 ft) plastic housing: 245 g (0.54 lbs) *Optional sensor mount for use with SBE 19plus V2:* 225 g (0.50 lbs)

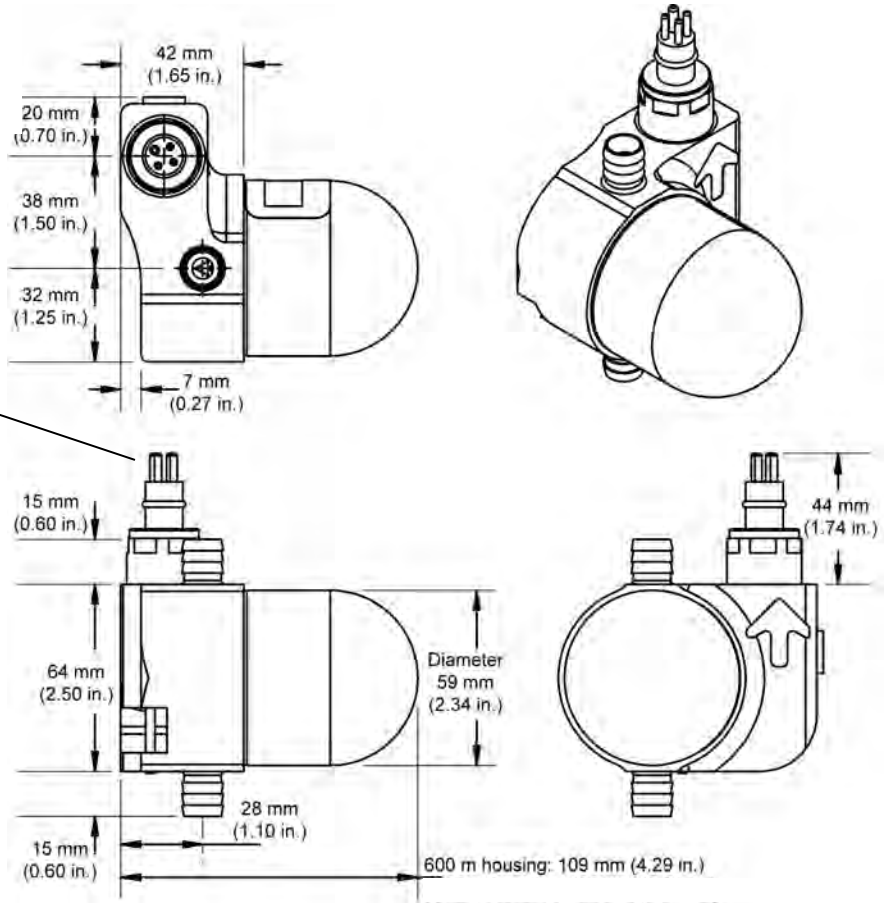
Dimensions and Connector

Hydro-DO sensor for integration with HydroCAT



Hydro-DO sensor installed in sensor mount, for use with RS-232 auxiliary sensor channel on CTD (SBE 19plus V2 SeaCAT)




42 mm (1.65 in.)
20 mm (0.70 in.)
38 mm (1.50 in.)
32 mm (1.25 in.)
7 mm (0.27 in.)
15 mm (0.60 in.)
64 mm (2.50 in.)
Diameter 59 mm (2.34 in.)
28 mm (1.10 in.)
15 mm (0.60 in.)
44 mm (1.74 in.)
600 m housing: 109 mm (4.29 in.)

Section 3:
Preparing Hydro-DO for Deployment

This section describes installing software and testing power and communications.

Software Installation

Notes:
- Help files provide detailed information on the software.
- It is possible to use the Hydro-DO without the SeatermV2 terminal program by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

Seasoft V2 was designed to work with a PC running Windows XP service pack 2 or later, Windows Vista, or Windows 7.

If not already installed, install SeatermV2 and other Sea-Bird software programs on your computer using the supplied software CD:

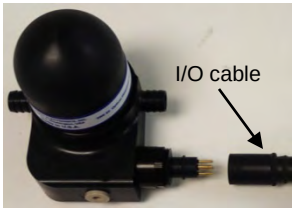
1. Insert the CD in your CD drive.

2. Install software: Double click on **SeasoftV2.exe**. Follow the dialog box directions to install the software. The installation program allows you to install the desired components. Install all the components, or just install SeatermV2, Seasave V7, and SBE Data Processing.

The default location for the software is c:\Program Files\Sea-Bird. Within that folder is a sub-directory for each program.

Power and Communications Test

Note:
Hydro-DO integrated with a HydroCAT: See the **HydroCAT manual** for information on communicating with the Hydro-DO **through** the HydroCAT.



The power and communications test will verify that the system works, prior to deployment.

Test Setup

1. Remove dummy plug (if applicable):
   A. By hand, unscrew the locking sleeve from the Hydro-DO's bulkhead connector. **If you must use a wrench or pliers, be careful not to loosen the bulkhead connector instead of the locking sleeve**.
   B. Remove the dummy plug from the Hydro-DO's I/O bulkhead connector by pulling the plug firmly away from the connector.

2. **XSG Connector** - Install the I/O cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - common) on the Hydro-DO sensor mount. **OR**
   MCBH Connector – Install the I/O cable connector, aligning the pins.

3. Connect the I/O cable connector to your computer's serial port.

4. Connect the I/O cable connector's red (+) and black (-) wires to a power supply (6 – 24 VDC).

Test

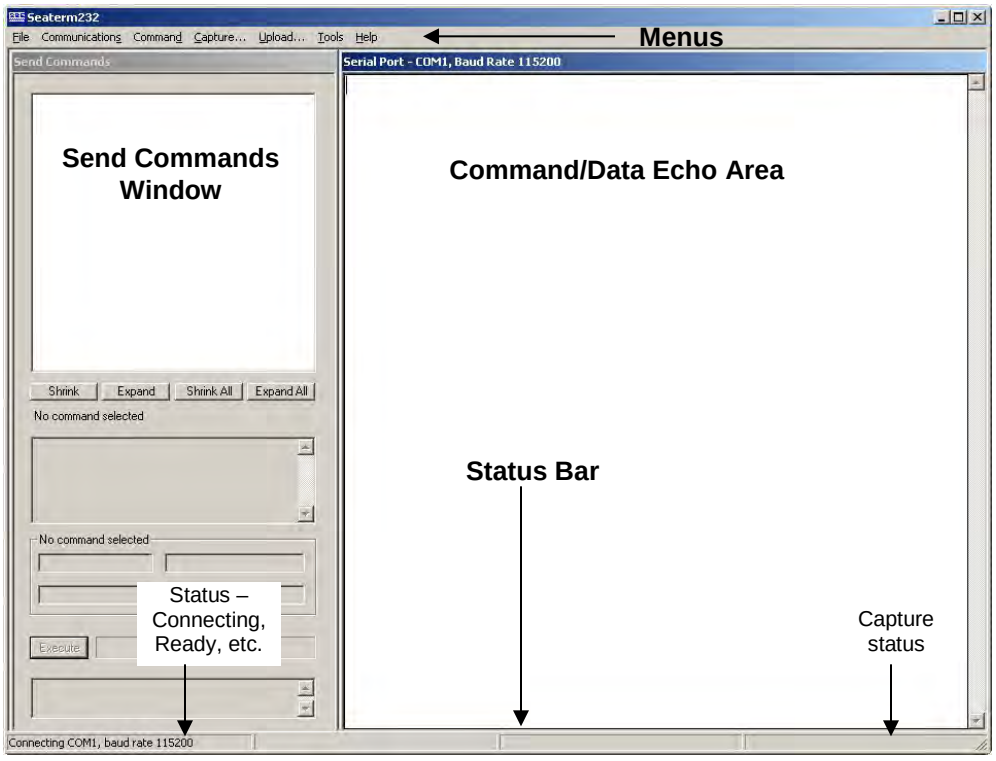
Notes:
- You can use any terminal program to set up the Hydro-DO; set it to 8 data bits, no parity, 1 stop bit, and 9600 baud (default Hydro-DO baud rate). Instructions here are for using SeatermV2.
- See SeatermV2's Help files.

1. Double click on **SeatermV2.exe**. The main screen looks like this:

SeatermV2 is a *launcher*. Depending on the instrument selected, it launches Seaterm232 (RS-232 instruments), Seaterm485 (RS-485 instruments), or SeatermIM (inductive modem instruments).

Notes:
- The Hydro-DO is based on Sea-Bird Electronics' SBE 63.
- See Seaterm232's Help files.

2. In the Instruments menu, select *SBE 63 Dissolved Oxygen Sensor*. **Seaterm232** opens; the main screen looks like this:



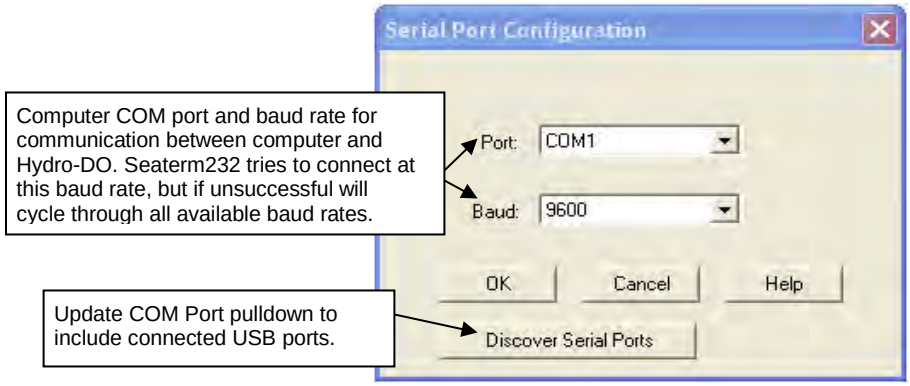
- Menus – For tasks and frequently executed instrument commands.
- Send Commands window – Contains commands applicable to your Hydro-DO. The list appears after you connect to the Hydro-DO.
- Command/Data Echo Area – Title bar of this window shows Seaterm232's current comm port and baud rate. Commands and the Hydro-DO responses are echoed here. Additionally, a command can be manually typed or pasted (ctrl + V) here. Note that the Hydro-DO must be *connected* and *awake* for it to respond to a command.
- Status bar – Provides connection, script, and capture status information.

Following is a description of the menus:

Menu	Description	Equivalent Command*
File	• Load command file – opens selected .XML command file, and fills Send Commands window with commands • Unload command file – closes command file, and removes commands from Send Commands window • Exit - Exit program.	—
Communications	• Connect – connect to comm port • Disconnect – disconnect from comm port • Configure – Establish communication parameters (comm port and baud rate). • Disconnect and reconnect – may be useful if Hydro-DO has stopped responding	—
Command	• Abort – interrupt and stop Hydro-DO response • Send stop command Remaining menu items are not applicable to Hydro-DO	• (press Esc key) • **Stop**
Capture	Capture Hydro-DO responses on screen to file, to save real-time data or use for diagnostics. File has .cap extension. Click Capture again to turn off capture. Capture status displays in Status bar.	—
Upload	Not applicable to Hydro-DO	—
Tools	• Diagnostics log - Keep a diagnostics log. • Convert .XML data file – not applicable to Hydro-DO • Send script – Send XML script to Hydro-DO. May be useful if you have a number of Hydro-DOs to program with same setup.	—

*See *Command Descriptions* in *Section 4: Deploying and Operating Hydro-DO*.

3. If this is the first time Seaterm232 is being used, the Serial Port Configuration dialog box displays:


Serial Port Configuration
Computer COM port and baud rate for communication between computer and Hydro-DO. Seaterm232 tries to connect at this baud rate, but if unsuccessful will cycle through all available baud rates.
Port:
COM1
Baud:
9600
OK
Cancel
Help
Update COM Port pulldown to include connected USB ports.
Discover Serial Ports

Make the desired selections, and click OK.

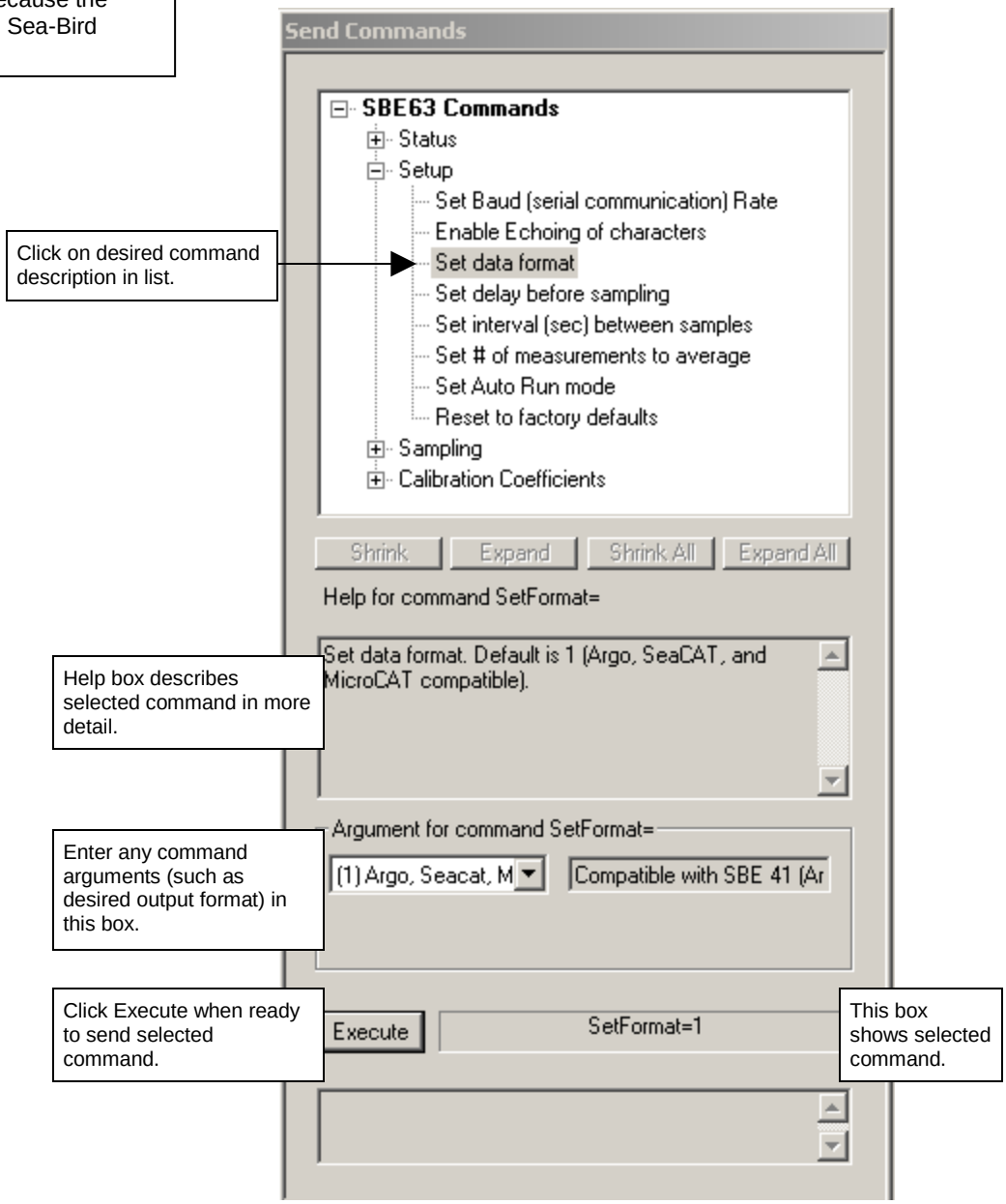
Note:
Seaterm232's baud rate must be the same as the Hydro-DO baud rate (set with **SetBaud=**). Baud is factory-set to 9600, but can be changed by the user (see *Command Descriptions* in *Section 4: Deploying and Operating Hydro-DO*). Other communication parameters – 8 data bits, 1 stop bit, and no parity – cannot be changed.

4. Seaterm232 tries to automatically connect to the Hydro-DO. As it connects, it sends **GetHD** and displays the response, which provides factory-set data such as instrument type, serial number, and firmware version. Seaterm232 also fills the Send Commands window with the correct list of commands for your Hydro-DO.
   If there is no communication:
   A. In the Communications menu, select *Configure*. The Serial Port Configuration dialog box appears. Select the Comm port and baud rate for communication, and click OK. Note that the factory-set baud rate is documented on the Configuration Sheet. .
   B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). Seaterm232 will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.
   C. If there is still no communication, check cabling between the computer and Hydro-DO, and try to connect again.
   D. If there is still no communication, repeat Step A with a different comm port, and try to connect again.

   After Seaterm232 displays the **GetHD** response, it provides an S> prompt to indicate it is ready for the next command.

Note:
The Command list says *SBE 63 Commands* because the Hydro-DO is based on Sea-Bird Electronics' SBE 63.

Taking a look at the Send Commands window:


Send Commands
SBE63 Commands
Status
Setup
Set Baud (serial communication) Rate
Enable Echoing of characters
Set data format
Set delay before sampling
Set interval (sec) between samples
Set # of measurements to average
Set Auto Run mode
Reset to factory defaults
Sampling
Calibration Coefficients
Shrink
Expand
Shrink All
Expand All
Help for command SetFormat=
Set data format. Default is 1 (Argo, SeaCAT, and MicroCAT compatible).
Argument for command SetFormat=
(1) Argo, Seacat, M
Compatible with SBE 41 (Ar
Execute
SetFormat=1
Click on desired command description in list.
Help box describes selected command in more detail.
Enter any command arguments (such as desired output format) in this box.
Click Execute when ready to send selected command.
This box shows selected command.

You can use the Send Commands window to send commands, or simply type the commands in the Command/Data Echo area if desired.

Notes:
The **GetHD** response outputs *SBE063* as the device type because the Hydro-DO is based on Sea-Bird Electronics' SBE 63. The serial number is xxxx, where xxxx is the last 4 digits of the serial number on the Hydro-DO's label (for example, *HDO-50013* on the label appears as *0013* in the **GetHD** response.

5. Display Hydro-DO setup and hardware information by typing **GetHD** and pressing the Enter key. The display looks like this:

```
<HardwareData DeviceType = 'SBE063' SerialNumber = '0013'>
   <Manufacturer>Sea-Bird Electronics, Inc.</Manufacturer>
   <FirmwareVersion>3.101</FirmwareVersion>
   <FirmwareDate>May 14 2013 10:37:51</FirmwareDate>
   <CommandSetVersion>1.3</CommandSetVersion>
   <MFGDate>04850</MFGDate>
   <PCBAssembly>41755</PCBAssembly>
   <PCBSerialNum>56556</PCBSerialNum>
   <PCBAssembly>41756</PCBAssembly>
   <PCBSerialNum>57151</PCBSerialNum>
   <FilmSerialNum>00077</FilmSerialNum>
   <Supply Voltage>8.63</Supply Voltage>
   <LoaderVersion>SBE 63 FirmwareLoader V 1.0</LoaderVersion>
   <CalibrationDate>04861</CalibrationDate>
   <HardwareConfig>
      <BaudRate>009600</BaudRate>
      <BlueOnTime>0000000</BlueOnTime>
      <SampleAvg>002</SampleAvg>
      <SampleInterval>00004</SampleInterval>
      <BootDelay>001</BootDelay>
      <OutFormat>01</OutFormat>
      <AnalogGain>2</AnalogGain>
      <AnalogOffset>00</AnalogOffset>
      <AutoRun>0</AutoRun>
      <BlueTupdate>0</BlueTupdate>
      <SerPause>1</SerPause>
      <Echo>1</Echo>
      <TxPwrSave>0</TxPwrSave>
      <Flags>0x0023</Flags>
   </HardwareConfig>
</HardwareData>
```

6. Command the Hydro-DO to take a sample by typing **TS** and pressing the Enter key. The display looks like this (if Hydro-DO is set up with **SetFormat=1**):

   ```
   16.411,0.550736,5.980,25.0011
   ```

   where 16.411 = raw phase delay
   0.550736 = raw thermistor voltage
   5.980 = converted oxygen in ml/l
   25.0011 = temperature in deg C

The Hydro-DO is ready for programming and deployment.

Section 4:
Deploying and Operating Hydro-DO

This section provides instructions for deploying the Hydro-DO. It includes:

- Sampling modes, including example sets of commands
- Command descriptions
- Data output formats
- Deployment
- Recovery

Note:
Separate software manuals and Help files contain detailed information on installation, setup, and use of Sea-Bird's software.

Sampling Modes

Notes:
- Sea-Bird ships the Hydro-DO with **SetAutoRun=0** (it will not automatically start sampling when power is applied). If you previously sent **SetAutoRun=1** (it automatically started sampling when power was applied), press the Esc key to stop sampling. You will then be able to send commands to change the setup.
- Hydro-DO response to commands is not shown in examples.

The Hydro-DO has two sampling modes for obtaining data:
- Polled Sampling
- Autonomous Sampling

Shown below are descriptions and examples of the two sampling modes. Note that the Hydro-DO's response to each command is not shown in the examples. Review the operation of the sampling modes and the commands described in *Command Descriptions* before setting up your system.

Polled Sampling

On command (**TS** or **TSR**), the Hydro-DO takes one sample of data and transmits the data.

Example 1: ***Polled Sampling*** (user input in bold).

Set up to wait for a command upon power up (**SetAutoRun=0**). Set up to echo commands (**SetEcho=1**), output converted oxygen and temperature data (**SetFormat=0**), and average 2 measurements/sample (**SetAvg=2**). Verify setup with status (**GetHD**) command. Remove power.

(Apply power, then select Connect in Seaterm232's Communications menu to connect and wake up.)
S>**SETAUTORUN=0**
S>SETECHO=1
S>**SETFORMAT=0**
S>**SETAVG=2**
S>**GETHD** (to verify setup)
(Remove power.)

When ready to take a sample (repeat as desired): apply power, establish communications with Hydro-DO, command it to take a sample and output data in format established with **SetFormat=**, and remove power.

(Apply power, then select *Connect* in Seaterm232's Communications menu to connect and wake up.)
(Before first sample, click Capture menu to capture data to a file – Seaterm232 requests file name for data to be stored.)
S>**TS**
(Remove power.)

Examples continued on next page

Note:
When using the Hydro-DO with an SBE 19*plus* V2 CTD, the following setup in the **Hydro-DO** is required:

- **SetBaud=** to the baud rate set in the CTD
- **SetEcho=1**
- **SetFormat=1**
- **SetAvg=1 to 16; recommended value is 2**
- **SetAutoRun=0**

In the **19*plus* V2**, if it is set to moored mode (**MM**), set:

- Pump mode to 2 (**MooredPumpMode=2**).
- Delay before sampling (**DelayBeforeSampling**=) to 25 sec at 15 °C to 40 sec at 0 °C (linear interpolation between those values). This provides enough time for the Hydro-DO to equilibrate after pumping begins, before the measurement is made.

In the CTD, the interval between samples (**SampleInterval=**) must be greater than or equal to the sum of the times required to sample. Total time is affected by the following:
- Minimum time required for CTD to take a sample (≈ 2.5 sec).
- Time required for CTD to take and average **NCycles=** samples; samples are taken 0.25 sec apart.
- Delay after providing power to external sensors before sampling (**DelayBeforeSampling=**); described above.
- Delay after sampling before turning off power to external sensors (**DelayAfterSampling=**).

Example 2: ***Polled Sampling with SBE 19plus V2*** (user input in bold).

Set up to wait for a command upon power up (**SetAutoRun=0**). Set up to echo commands (**SetEcho=1**), average 2 measurements per output sample (**SetAvg=2**), and output data in a format compatible with 19*plus* V2 (**SetFormat=1**). Set Hydro-DO baud rate to same baud as 19*plus* V2 (assume 9600 baud for this example). Verify setup with status (**GetHD**) command. Remove power.

(Apply power to Hydro-DO, then select Connect in Seaterm232's Communications menu to connect to and wake up Hydro-DO.)

S>**SETAUTORUN=0**
S>SETECHO=1
S>**SETAVG=2**
S>**SETFORMAT=1**
S>**SETBAUD=9600** (get message to re-enter baud)
S>**SETBAUD=9600**

(In Seaterm232's Communications menu, select Configure. Change baud to 9600 and click OK. In Seaterm232's Communications menu, select disconnect and reconnect. You will now be communicating at new baud).

S>**GETHD** (to verify setup)

(Remove power from Hydro-DO.)

When ready to begin sampling: Connect Hydro-DO to 19*plus* V2 RS-232 auxiliary sensor connector. Set 19*plus* V2 to moored mode (**MM**) and set the sampling interval (**SampleInterval**=) Start autonomous sampling in 19*plus* V2 (see 19*plus* V2 manual). Each time SBE 19*plus* V2 takes a measurement, it applies power to and requests a sample from Hydro-DO using **TS** command.

When ready to stop sampling: Stop autonomous sampling in 19*plus* V2.

Autonomous Sampling

The Hydro-DO does not have an internal (standby) real-time clock. Therefore, once you start autonomous sampling, power to the Hydro-DO must remain on for autonomous sampling to continue at the specified interval.

Note:
Sea-Bird ships the Hydro-DO with **SetAutoRun=0** (it will not automatically start sampling when power is applied). If you send **SetAutoRun=1**, turn power off and then on again to start sampling, or send **Start**.

SetAutoRun defines how sampling starts:

SetAutoRun=	To Start Autonomous Sampling	To Stop Autonomous Sampling
0 (default)	Send **Start**.	• Turn off power, **or** • Click Esc (stopping this way allows you to then send commands to check/modify the setup), **or** • Send **Stop** (stopping this way allows you to then send commands to check/modify the setup).
1	Turn on power.	

Example 1: ***Autonomous Sampling Setup for SetAutoRun=0*** **(user input in bold).**

Set up to wait for a command upon power up (**SetAutoRun=0**).
Set up to echo commands (**SetEcho=1**), take and output a sample every 10 sec (**SetInterval=10**), averaging 2 measurements per output sample (**SetAvg=2**), and output converted oxygen and temperature data (**SetFormat=0**). Verify setup with status (**GetHD**) command. Remove power.

(Apply power, then select Connect in Seaterm232's Communications menu to connect and wake up.)

S>**SETAUTORUN=0**
S>**SETECHO=1**
S>**SETINTERVAL=10**
S>**SETAVG=2**
S>**SETFORMAT=0**
S>**GETHD** (to verify setup)
(Remove power.)

When ready to begin sampling:

(Apply power, then select Connect in Seaterm232's Communications menu to connect and wake up.)

S>**START**

When ready to stop sampling:

(Send **Stop**, click Esc, or remove power.)

Examples continued on next page

Example 2: ***Autonomous Sampling Setup for SetAutoRun=1*** **for use with power supply and logger.**

Set up to start sampling when power is applied (**SetAutoRun=1**).
Set up to echo commands (**SetEcho=1**), take samples at 10-sec intervals (**SetInterval=10**), average 2 measurements per output sample (**SetAvg=2**), output converted oxygen and temperature data (**SetFormat=0**), and set the delay before sampling to the minimum value (**SetBootDelay=**). Verify setup with status (**GetHD**) command. Remove power.

(Apply power, then select Connect in Seaterm232's Communications menu to connect and wake up.)

S>**SETAUTORUN=1**
S>SETECHO=1
S>**SETINTERVAL=10**
S>**SETAVG=2**
S>**SETFORMAT=0**
S>**SETBOOTDELAY=1**
S>**GETHD** (to verify setup)
(Remove power from Hydro-DO.)

When ready to begin sampling, connect Hydro-DO to power supply and data logger.

(Apply power – Hydro-DO automatically begins sampling at 10-sec intervals.)

When ready to stop sampling:
(remove power.)

Command Descriptions

This section describes commands and provides sample outputs.
See *Appendix III: Command Summary* for a summarized command list.

When entering commands:

- Input commands to the Hydro-DO in upper or lower case letters and register commands by pressing the Enter key (0xD).
- Commands to enable a parameter can be entered with the *argument* as Y or 1 for yes, and N or 0 for no (for example, **SetAutoRun=y** and **SetAutoRun=1** are equivalent; both enable automatic starting of sampling when power is applied).
- The Hydro-DO sends `Command failed: Unknown command` if an invalid command is entered.
- If the Hydro-DO does not return an `S>` prompt after executing a command, press the Enter or Esc key to get the `S>` prompt.
- If the Hydro-DO is transmitting data and you want to stop it, press the Esc key or send **Stop**. Alternatively, remove power.
- All commands that change setup take effect immediately, and are committed to nonvolatile storage (Hydro-DO retains settings when power is removed).

Status Command

Notes:
- All Status command responses output *SBE063* as the device type because the Hydro-DO is based on Sea-Bird Electronics' SBE 63.
- The serial number in the status responses is xxxx, where xxxx is the last 4 digits of the serial number on the Hydro-DO's label (for example, *HDO-50013* on the label appears as *0013* in the status responses.

GetSD

Get and display status data, which includes all parameters related to setup that can be input/modified. Many parameters are not user-programmable (programmed at factory). List and example include commands used to modify user-programmable parameters:
- Instrument type and serial number
- Firmware version
- Firmware date
- Command set version
- Software used to upload firmware to Hydro-DO
- Calibration date (days since 1/1/2000)
- Communication baud rate [**SetBaud=**]
- Blue LED counter total on-time (sec)
- Number of measurements to average per sample [**SetAvg=**]
- Interval between samples for autonomous sampling [**SetInterval=**]
- Delay before sampling after power is applied [**SetBootDelay=**]
- Data output format [**SetFormat=**]
- Analog gain and offset
- Begin sampling automatically when power applied [**SetAutoRun=**]?
- Update Blue LED counter with every sample?
- Serial pause (factory set; must be 1 for use with SBE 19*plus* V2 in Profiling mode; can be 0 or 1 for other applications).
- Enable echoing [**SetEcho=**]?
- Power save mode, 0 or 1 (factory set; 0 for all applications)
- Internally calculated [based on settings]

Example: (user input in bold)

```
S>getsd
<StatusData DeviceType = 'SBE063' SerialNumber = '0013'>
   <FirmwareVersion>3.1.0</FirmwareVersion>
   <FirmwareDate>May 14 2013 10:37:51</FirmwareDate>
   <CommandSetVersion>1.3</CommandSetVersion>
   <LoaderVersion>SBE 63 FirmwareLoader V 1.0</LoaderVersion>
   <CalibrationDate>04861</CalibrationDate>
   <StatusConfig>
      <BaudRate>009600</BaudRate>                                  [SetBaud=]
      <BlueOnTime>0000000</BlueOnTime>
      <SampleAvg>002</SampleAvg>                                   [SetAvg=]
      <SampleInterval>00004</SampleInterval>                       [SetInterval=]
      <BootDelay>001</BootDelay>                                   [SetBootDelay=]
      <OutFormat>01</OutFormat>                                    [SetFormat=]
      <AnalogGain>2</AnalogGain>
      <AnalogOffset>00</AnalogOffset>
      <AutoRun>0</AutoRun>                                         [SetAutoRun=]
      <BlueTupdate>0</BlueTupdate>
      <SerPause>1</SerPause>
      <Echo>1</Echo>                                               [SetEcho=]
      <TxPwrSave>0</TxPwrSave>
      <Flags>0x0023</Flags>          [internally calculated, based on SetAutoRun= and factory settings]
   </StatusConfig>
</StatusData>
```

Status Command *(continued)*

GetHD

Get and display hardware data. Many parameters are not user-programmable, and are programmed at the factory. List and example include commands used to modify user-programmable parameters:

- Instrument type and serial number
- Manufacturer
- Firmware version
- Firmware date
- Command set version
- Manufacture date (days since 1/1/2000)
- PCB assemblies and serial numbers
- Optical film serial number
- Power supply voltage seen by Hydro-DO
- Software used to upload firmware to Hydro-DO
- Calibration date (days since 1/1/2000)
- Communication baud [**SetBaud=**]
- Blue LED counter total on-time (sec)
- Number of measurements to average per sample [**SetAvg=**]
- Interval between samples for autonomous sampling [**SetInterval=**]
- Delay before sampling after power is applied [**SetBootDelay=**]
- Data output format [**SetFormat=**]
- Analog gain and offset
- Begin sampling automatically when power applied [**SetAutoRun=**]?
- Update Blue LED counter with each sample?
- Serial pause (factory set; must be 1 for use with SBE 19*plus* V2 in Profiling mode; can be 0 or 1 for other integrations).
- Enable echoing [**SetEcho=**]?
- Power save mode, 0 or 1 (factory set; 0 for all applications)
- Internally calculated [based on settings]

Example: (user input in bold)

```
S>gethd
<HardwareData DeviceType = 'SBE063' SerialNumber = '0013'>
   <Manufacturer>Sea-Bird Electronics, Inc.</Manufacturer>
   <FirmwareVersion>3.1.0</FirmwareVersion>
   <FirmwareDate>May 14 2013 10:37:51</FirmwareDate>
   <CommandSetVersion>1.3</CommandSetVersion>
   <MFGDate>04850</MFGDate>
   <PCBAssembly>41755</PCBAssembly>
   <PCBSerialNum>56556</PCBSerialNum>
   <PCBAssembly>41756</PCBAssembly>
   <PCBSerialNum>57151</PCBSerialNum>
   <FilmSerialNum>00077</FilmSerialNum>
   <Supply Voltage>8.63</Supply Voltage>
   <LoaderVersion>SBE 63 FirmwareLoader V 1.0</LoaderVersion>
   <CalibrationDate>04861</CalibrationDate>
   <HardwareConfig>
      <BaudRate>009600</BaudRate>                                  [SetBaud=]
      <BlueOnTime>0000000</BlueOnTime>
      <SampleAvg>002</SampleAvg>                                   [SetAvg=]
      <SampleInterval>00004</SampleInterval>                       [SetInterval=]
      <BootDelay>001</BootDelay>                                   [SetBootDelay=]
      <OutFormat>01</OutFormat>                                    [SetFormat=]
      <AnalogGain>2</AnalogGain>
      <AnalogOffset>00</AnalogOffset>
      <AutoRun>0</AutoRun>                                         [SetAutoRun=]
      <BlueTupdate>0</BlueTupdate>
      <SerPause>1</SerPause>
      <Echo>1</Echo>                                               [SetEcho=]
       <TxPwrSave>0</TxPwrSave>
      <Flags>0x0023</Flags>          [internally calculated, based on SetAutoRun= and factory settings]
   </HardwareConfig>
</HardwareData>
```

Status Command *(continued)*

GetCC

Get and display calibration coefficients, which are initially factory-set and should agree with Calibration Certificate shipped with Hydro-DO. Example below includes, where applicable, command used to modify parameter.

- <CalDate> is number of days since January 1, 2000.
- **SetRefSal=** and **SetRefP=** are set by user; see description below in *Calibration Coefficients* section of these command descriptions

Example: (user input in bold)

```
S>getcc
<CalibrationCoefficients DeviceType = 'SBE063' SerialNumber = '0013'>
   <Calibration format = 'TEMP1' id = 'Temperature'>
      <SerialNum>06300013</SerialNum>
      <CalDate>04861</CalDate>
      <TA0>+5.593530e-04</TA0>                                    [SetTA0=]
      <TA1>+2.756939e-04</TA1>                                    [SetTA1=]
      <TA2>-1.453041e-06</TA2>                                    [SetTA2=]
      <TA3>+1.535286e-07</TA3>                                    [SetTA3=]
   </Calibration>
   <Calibration format = 'OX1' id = 'OptOxygen'>
      <SerialNum>06300013</SerialNum>
      <CalDate>04861/CalDate>
      <A0>+8.900000e-01</A0>                                      [SetA0=]
      <A1>-1.520000e-03</A1>                                      [SetA1=]
      <A2>+0.000000e+00</A2>                                      [SetA2=]
      <B0>-1.820000e-01</B0>                                      [SetB0=]
      <B1>+1.086300e+00</B1>                                      [SetB1=]
      <C0>+1.737200e-01</C0>                                      [SetC0=]
      <C1>+6.545500e-03</C1>                                      [SetC1=]
      <C2>+8.945700e-05</C2>                                      [SetC2=]
      <E>-2.600000e-03</E>                                        [SetE=]
      <SOLB0>-6.245230e-03</SOLB0>                                [SetSolB0=]
      <SOLB1>-7.376141e-03</SOLB1>                                [SetSolB1=]
      <SOLB2>-1.034100e-02</SOLB2>                                [SetSolB2=]
      <SOLB3>-8.170830e-03</SOLB3>                                [SetSolB3=]
      <SOLC0>-4.886820e-07</SOLC0>                                [SetSolC0=]
      <REFSALpsu>+0.000000e+00</REFSALpsu>                        [SetRefSal=]
      <REFPRESSdbar>+0.000000e+00</REFPRESSdbar>                  [SetRefP=]
   </Calibration>
</CalibrationCoefficients>
```

Status Command *(continued)*

DS

Get and display status data in non-XML format. Many parameters are not user-programmable, and are programmed at the factory. List and example include commands used to modify user-programmable parameters:

- Instrument type
- Instrument serial number
- PCB assemblies and serial numbers
- Optical film serial number
- Firmware version and date
- Software used to upload firmware to Hydro-DO
- Manufacturing date (days since 1/1/2000)
- Calibration date (days since 1/1/2000)
- Power supply voltage seen by Hydro-DO
- Communication baud rate [**SetBaud=**]
- Analog gain
- Analog offset
- Blue LED counter total on-time (sec)
- Number of measurements to average per sample [**SetAvg=**]
- Interval between samples for autonomous sampling [**SetInterval=**]
- Delay before sampling after power is applied [**SetBootDelay=**]
- Data output format [**SetFormat=**]
- Begin sampling automatically when power applied [**SetAutoRun=**]?
- Update Blue LED counter with every sample?
- Serial pause (factory set; must be 1 for use with SBE 19*plus* V2 in Profiling mode; can be 0 or 1 for other applications).
- Enable echoing [**SetEcho=**]?
- Power save mode, 0 or 1 (factory set; 0 for all applications)
- Internally calculated [based on settings]

Example: (user input in bold)

```
S>ds
Model               =   SBE63 rev J
Serial#             =   0442
PCBID Analog        =   41755 SN56556
PCBID Digital       =   41756 SN57151
Sensor Film Serial# =   00077
Firmware Rev        =   3.1.0 May 14 2013 10:37:51
Firmware Loader Ver =   SBE 63 FirmwareLoader V 1.0
MFG days +1/1/2000  =   4850
CAL days +1/1/2000  =   4861
Supply Voltage      =   8.29
Baudrate            =   9600                                    [SetBaud=]
Analog Gain         =   02
Analog Offset       =   00
Blue On-time [sec]  =   00
Samples Averaged    =   02                                      [SetAvg=]
Sample Intvl [sec]  =   0004                                    [SetInterval=]
Boot Delay [sec]    =   001                                     [SetBootDelay=]
Output format       =   01                                      [SetFormat=]
Autorun [0/1]       =   0                                       [SetAutoRun=]
BlueTUpdate [0/1]   =   0
SerPause [0/1]      =   1
Echo [0/1]          =   1                                       [SetEcho=]
TxPwrsave [0/1]     =   0
Flags               =   0x23        [internally calculated, based on SetAutoRun= and factory settings]
```

Setup Commands

Note:
When communicating directly with the Hydro-DO, the Hydro-DO's baud rate (set with **SetBaud=**) must be the same as Seaterm232's baud rate (set in the Communications menu).

Note:
When using the Hydro-DO with an SBE 19*plus* V2 CTD, the following setup in the **Hydro-DO** is required:
- **SetBaud=** to the baud rate set in the CTD
- **SetEcho=1**
- **SetFormat=1**
- **SetAvg=1 to 16; recommended value is 2**
- **SetAutoRun=0**

In the **CTD**, set:
- Pump mode to 2 (**PumpMode=2**).
- Delay before sampling (**DelayBeforeSampling**=) to 25 sec at 15 °C to 40 sec at 0 °C (linear interpolation between those values). This provides enough time for the Hydro-DO to equilibrate after pumping begins, before the measurement is made.

In the CTD, the interval between samples (**SampleInterval=**) must be greater than or equal to the sum of the times required to sample. Total time is affected by the following:
- Minimum time required for CTD to take a sample (≈ 2.5 sec).
- Time required for integration of optional Quartz pressure sensor (**ParosIntegration=**).
- Time required for CTD to take and average **NCycles=** samples; samples are taken 0.25 sec apart.
- Delay after providing power to external sensors before sampling (**DelayBeforeSampling=**); described above.
- Delay after sampling before turning off power to external sensors (**DelayAfterSampling=**).

SetBaud=x

x= baud rate (600, 1200, 2400, 4800, 9600, 19200, 33600, 38400, 57600, or 115200). ***Default 9600.*** Check capability of your computer and terminal program before increasing baud rate; high baud rates require a short cable and good PC serial port with accurate clock. Hydro-DO requires you to enter command twice to confirm.

Example: (user input in bold).

```
S>setbaud=19200
Baud change requested.
Re-enter setbaud command at OLD baudrate to confirm
S>setbaud=19200
```

(may then show *garbage* characters, because of baud rate change)
(In Seaterm232's Communications menu, select *Configure*. Change baud to 19200 and click OK. In Seaterm232's Communications menu, select *Disconnect and reconnect*).
S> (now communicating at 19200 baud)

SetEcho=x

x=1: Echo characters received from computer; monitor shows entered commands as you type. Provides compatibility with SeaCATs (SBE 19*plus* V2), and HydroCATs. ***Default.***

x=0: Do not.

SetFormat=x

Data output format (see *Data Formats* for details):

x=0: Converted oxygen and temperature (with units).

x=1: Raw phase delay and thermistor voltage, converted oxygen and temperature (no units), for compatibility with SeaCATs (19*plus* V2), and HydroCATs. ***Default.***

x=2: Raw and converted data.

x=3: Instrument name, serial number, and converted oxygen.

SetBootDelay=x

x= delay after power is applied before sampling (1 - 255 sec). ***Default 1.*** Only applicable if **AutoRun=1**.

SetInterval=x

x= interval between samples (1 – 32,767 sec) for autonomous sampling (if power remains on, and **Start** has been sent or **AutoRun=1)**. ***Default 4.***

Setup Commands *(continued)*

Note:
If more time is required than provided by **SetInterval** (can only occur if **SetInterval** is small and **SetAvg** is large), the sample is delayed until all the measurements defined by **SetAvg** are completed.

SetAvg=x

x = number of measurements to take and average per sample (1–64, or 1–32 for 1Hz sampling); ***default 2***. Each additional measurement adds approximately 0.0167 sec. Increasing **SetAvg=** shortens sensor film life and increases photo-bleaching effects. **Sea-Bird recommends SetAvg=2 for best results,** to prevent calibration shifts caused by film heating and photo bleaching-effects.

Note:
To start autonomous sampling after you send **SetAutoRun=1**:
- turn power off and then on again, or
- send **Start** or **Go**

SetAutoRun=x

x=0: Wait for command when power applied. ***Default.*** Required setting for use with SeaCATs (19*plus* V2), and HydroCATs.

x=1: Begin sampling when power applied. First sample taken after **SetBootDelay=**.

***Default**

Reset most Setup parameters to their factory defaults (**SetEcho=1**, **SetFormat=1**, **SetBootDelay=1**, **SetInterval=4**, **SetAvg=2**, **SetAutoRun=0**). Baud (**SetBaud=**) is **not** reset.Also resets factory-set parameters SerPause (0), BlueTUpdate (0), TxPwrSave (0), Gain (2), and Offset (0).

Sampling Commands

Start or **Go**

Start autonomous sampling immediately at rate set by **SetInterval=**, and output data in format defined by **SetFormat=**. Applicable if:
- **SetAutoRun=0**, or
- **SetAutoRun=1**, and you previously clicked Esc to stop sampling.

To stop sampling:
- Click Esc or send **Stop** command. Once sampling is stopped and terminal program shows S> prompt, you can send desired commands (setup, status, etc.). **OR**
- Remove power.

Note:
You may need to click Esc or send **Stop** several times to get the Hydro-DO to respond.

Stop

Stop autonomous sampling. Command will not be echoed while autonomous sampling. S> prompt appears to signal that autonomous sampling has stopped.

TS

Take **1** sample and transmit data in format defined by **SetFormat=**.

TSR

Take **1** sample and transmit data in raw format (for factory diagnostics).

Calibration Coefficients Commands

With the exception of **SetRefSal=** and **SetRefP=**, calibration coefficients are initially factory-set and should agree with Calibration Certificate shipped with the Hydro-DO.

Note:
S = integer
F = floating point number

SetCalDate=S	**S=** calibration date (days since January 1, 2000).
SetTA0=F	**F=** TA0 coefficient.
SetTA1=F	**F=** TA1 coefficient.
SetTA2=F	**F=** TA2 coefficient.
SetTA3=F	**F=** TA3 coefficient.
SetA0=F	**F=** A0 coefficient.
SetA1=F	**F=** A1 coefficient.
SetA2=F	**F=** A2 coefficient.
SetB0=F	**F=** B0 coefficient.
SetB1=F	**F=** B1 coefficient.
SetC0=F	**F=** C0 coefficient.
SetC1=F	**F=** C1 coefficient.
SetC2=F	**F=** C2 coefficient.
SetE=F	**F=** E coefficient.
SetSolB0=F	**F=** SolB0 coefficient.
SetSolB1=F	**F=** SolB1 coefficient.
SetSolB2=F	**F=** SolB2 coefficient.
SetSolB3=F	**F=** SolB3 coefficient.
SetSolC0=F	**F=** SolC0 coefficient.
SetRefSal=F	**F**= Reference salinity (psu) to use for oxygen calculation in converted units. Default 0. For moored application, enter approximate value expected for deployment. For profiling applications, enter 0, and correct oxygen for salinity effect in post-processing.
SetRefP=F	**F**= Reference pressure (decibars) to use for oxygen calculation in converted units. Default 0. For moored application, enter value expected for deployment. For profiling applications, enter 0, and correct oxygen for pressure effect in post-processing.

Data Formats

Note about units for converted oxygen:
Sea-Bird uses the following equations to convert oxygen to various engineering units:
[mg/L] = [ml/L] * 1.42903
[micromole/Kg] = [ml/L] * 44660 / (sigma_theta(P,T,S) + 1000)

For the micromole/Kg conversion, there is disagreement in the scientific community about the conversion constant 44660:

- The value 44660 is exact for oxygen gas.
- The value 44615 is the average value for atmospheric gas (N2,O2,Ar,H2O,CO2,...). It is not exact for any individual gas, but has been used historically by oceanographers.

The argument distills to exact versus historic, with oceanographers split; Sea-Bird uses 44660 in all software calculations.

Notes:
- Each scan of data ends with a carriage return and line feed.
- Converted oxygen values (dissolved oxygen in ml/l) are dependent on the user-set **SetRefSal=** and **SetRefP=**.
- See *Appendix I: Functional Description* for details on the calibration equation and conversion of the raw data to dissolved oxygen in ml/l.

Following are the data formats:

- **SetFormat=0** – Converted oxygen and temperature with units:
  o.oooo ml/l, tt.tttt C
  where
  o.oooo = dissolved oxygen in ml/l
  tt.tttt = temperature in deg C

  Example: **SetFormat=0**
  `4.3019 ml/l, 25.2556 C`
  (converted oxygen, converted temperature)

- **SetFormat=1** (default) –SeaCAT (19*plus* V2) and HydroCAT:
  aa.aaa, b.bbbbbb, o.oooo, tt.tttt *where*
  aa.aaaa = raw phase delay (µsec)
  b.bbbb = raw thermistor voltage
  o.ooo = dissolved oxygen in ml/l
  tt.tttt = temperature in deg C

  Example: **SetFormat=1**
  `16.6423,0.641321,4.308,25.2553`
  (raw phase delay, raw thermistor voltage, converted oxygen, converted temperature)

- **SetFormat=2** – Raw and converted data:
  01/01/11 00:00:00 660 aaaaa *695* bbbbb *570* oooo ttttt
  where
  aaaaa = raw phase delay (x1000)
  bbbbb = raw thermistor voltage (x65536/3.30)
  oooo = dissolved oxygen in ml/l (x1000)
  ttttt = temperature in deg C (x1000)
  Italic numbers are constants, not used in calculations
  Each field is separated by a tab character.

  Example: **SetFormat=2**

  ```
  01/01/11    00:00:00    660         16649
  695         12736       570         4303
  25255
  ```

  (information in italics are constants not used in calculations; remaining information is raw phase delay x1000, raw thermistor voltage x1000, converted oxygen x1000, converted temperature x1000)

Note:
The Hydro-DO outputs *SBE63* as the device type because the Hydro-DO is based on Sea-Bird Electronics' SBE 63. The serial number is xxxx, where xxxx is the last 4 digits of the serial number on the Hydro-DO's label (for example, *HDO-50013* on the label appears as *0013* in the data.

- **SetFormat=3** – Instrument name, serial number, and converted oxygen:
  SBE63 ssss oo.ooo
  where
  ssss = Hydro-DO serial number
  oo.ooo = dissolved oxygen in ml/l (leading zero is not suppressed)
  Hydro-DO and serial number are separated by a tab character; serial number and dissolved oxygen are separated by two tab characters.

  Example: **SetFormat=3**

  ```
  SBE63       0013                    04.304
  ```

  (serial number, converted oxygen in ml/l)

Deployment

Note:
In the **19*plus* V2**, if it is set to moored mode (**MM**), set:
- Pump mode to 2 (**MooredPumpMode=2**).
- Delay before sampling (**DelayBeforeSampling**=) to 25 sec at 15 °C, 40 sec at 0 °C (linear interpolation between those values). This provides enough time for the Hydro-DO to equilibrate after pumping begins, before the measurement.

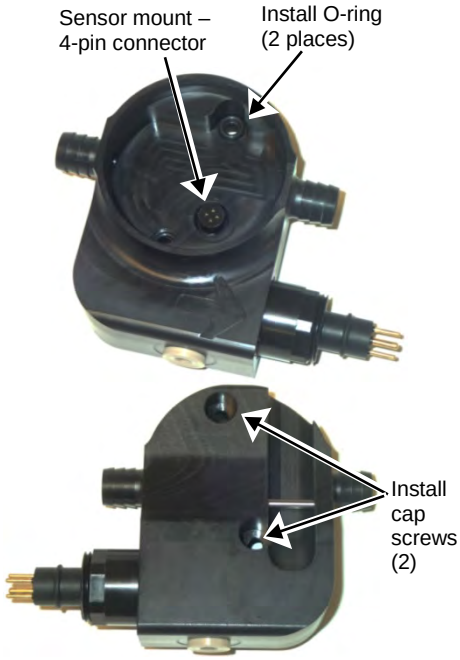
In the CTD, the interval between samples (**SampleInterval=**) must be ≥ sum of times required to sample. Total time is affected by:
- Minimum time for CTD to take sample (≈ 2.5 sec).
- Time for CTD to take and average **NCycles=** samples, taken 0.25 sec apart.
- Delay after providing power to external sensors before sampling (**DelayBeforeSampling=**); described above.
- Delay after sampling before turning off power to external sensors (**DelayAfterSampling=**).

Integration with SeaCAT CTD (SBE 19*plus* V2)

Prior to installing the Hydro-DO on the CTD, verify that the Hydro-DO is set up as follows (see *Section 3: Preparing Hydro-DO for Deployment* for details on communicating in Seaterm232; see *Command Descriptions* above for command details):
- **SetBaud=** to baud rate set in CTD
- **SetEcho=1**
- **SetAvg=1 to 16; recommended value is 2**
- **SetFormat=1**
- **SetAutoRun=0**

For use with the SBE 19*plus* V2 in Profiling mode, verify that <SerPause> in the **GetSD** or **GetHD** response is 1 (factory set). For the 19*plus* V2 in Moored mode, <SerPause> can be set to 0 or 1.

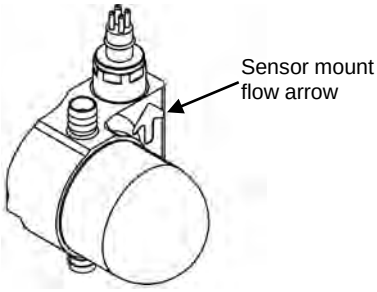
Verify that <TxPwrSave> in the **GetSD** or **GetHD** response is 0 (factory set).



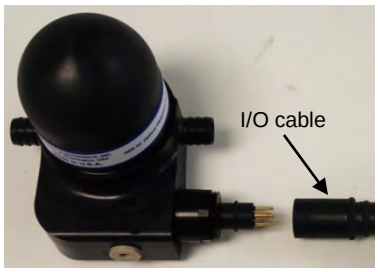
Install on the CTD as follows:

1. Install the Hydro-DO in the sensor mount:
   A. Place the two small O-rings on the sensor mount screw holes.
   B. Align the 4-pin connectors and push the Hydro-DO onto the mount.
   C. Install the two #10-24, 1/2" titanium cap screws from the back of the sensor mount to secure the Hydro-DO in the mount.

2. Mount the Hydro-DO on the CTD. Install Tygon tubing to connect the Hydro-DO inline between the CTD conductivity cell outlet and the pump inlet. Verify that the large arrow on the sensor mount is pointing in the direction of the flow (flow enters from the conductivity cell, and exits to the pump).



CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connector.



3. Install the I/O cable on the Hydro-DO sensor mount:
   A. Lightly lubricate the inside of the cable connector with silicone grease (DC-4 or equivalent).
   B. **XSG Connector** - Install the cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - ground) on the Hydro-DO sensor mount. Remove any trapped air by *burping* or gently squeezing the connector near the top and moving your fingers toward the end cap. **OR**
   MCBH Connector – Install the cable connector, aligning the pins.
   C. Place the locking sleeve over the connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**

4. Connect the I/O cable to the 4-pin RS-232 auxiliary sensor connector on the CTD, using the same technique as in Step 3 (see the CTD manual for the end cap detail).

5. Verify that the hardware and external fittings are secure.

The Hydro-DO is ready to go into the water.

Integration with HydroCAT CTD

The Hydro-DO is factory-integrated with the HydroCAT. You can communicate with the Hydro-DO **through** the HydroCAT with **Send63=command**; **command** can be any command recognized by the Hydro-DO. Verify that the Hydro-DO is set up as follows by sending **Send63=GetSD** (see *Command Descriptions* above for command details):

- **SetBaud=2400** (factory set; cannot be changed by command through the HydroCAT)
- **SetEcho=1**
- **SetAvg=1 to 16; recommended value is 2**
- **SetFormat=1**
- **SetAutoRun=0**

Verify that <TxPwrSave> in the **GetSD** or **GetHD** response is 0 (factory set).

Recovery

WARNING!
If the Hydro-DO stops working while underwater, is unresponsive to commands, or shows other signs of flooding or damage, carefully secure it away from people until you have determined that abnormal internal pressure does not exist or has been relieved. Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals. When a sealed pressure housing floods at great depths and is subsequently raised to the surface, water may be trapped at the pressure at which it entered the housing, presenting a danger if the housing is opened before relieving the internal pressure. Instances of such flooding are rare. However, a housing that floods at 6300 meters depth holds an internal pressure of more than 7000 psia, and has the potential to eject the end cap with lethal force. A housing that floods at 63 meters holds an internal pressure of more than 85 psia; this force could still cause injury.
If you suspect the Hydro-DO is flooded, point it in a safe direction away from people. Remove the Hydro-DO from the sensor mount (if applicable). Very slowly unscrew the Hydro-DO *dome*, letting the internal pressure bleed off slowly past the O-ring as the O-ring is released from the housing. Then, you can safely remove the dome.

Rinse the outside of the Hydro-DO with fresh water.

Section 5: Routine Maintenance and Calibration

This section reviews corrosion precautions, connector mating and maintenance, sensor maintenance, and sensor calibration. The accuracy of the Hydro-DO is sustained by establishing proper handling practices.

Corrosion Precautions

Rinse the Hydro-DO with fresh water after use and prior to storage.

All exposed metal is titanium; other materials are plastic. No corrosion precautions are required, but direct electrical connection of titanium to dissimilar metal hardware should be avoided.

Connector Mating and Maintenance

Note:
See *Application Note 57: Connector Care and Cable Installation* for the connection to the optional sensor mount.

Optional Sensor Mount:

Clean and inspect the connectors, cable, and dummy plug before every deployment and as part of your yearly equipment maintenance. Inspect connectors that are unmated for signs of corrosion product around the pins, and for cuts, nicks or other flaws that may compromise the seal.

When remating:

1. Lightly lubricate the inside of the cable connector with silicone grease (DC-4 or equivalent).

CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connector.

2. **XSG Connector** - Install the cable connector, aligning the raised bump on the side of the cable connector with the large pin (pin 1 - ground) on the Hydro-DO. Remove any trapped air by *burping* or gently squeezing the connector near the top and moving your fingers toward the end cap. **OR**
   MCBH Connector – Install the cable connector, aligning the pins.

3. Place the locking sleeve over the cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**

Verify that a cable is installed before deployment.

Sensor Maintenance

Procedures

CAUTIONS:
- During service and storage, maintain temperatures between 0 - 40 ºC (32 – 104 ºF).
- Do not use stronger solutions or longer wash times than recommended.
- Do not place Triton or bleach directly on the optical window.

Avoid fouling the optical window with oil or grease as this causes a calibration shift. An oil-fouled window can be cleaned using the following procedures.

- **Preventive Field Maintenance Between Profiles**: After each cast, flush with a **0.1%** solution of **Triton X-100**, using a 60 cc syringe (see Application Note 34). Then rinse thoroughly with fresh water. Between casts, ensure that the sensor remains shaded from direct sunlight and stays within the recommended temperature range.

- **Routine (post-cruise) Cleaning (no visible deposits or marine growths on sensor)** -- Follow this two-step procedure:
  1. **Flush** the sensor for **1** minute with a **1%** solution of **Triton X-100** warmed to 30 ºC (86 ºF). **Drain and flush** with warm (not hot) fresh water for **5 minutes.**
  2. **Soak** the sensor for **1** minute in a **500 - 1000 ppm** solution of **Bleach**. After the soak, **drain and flush** with warm (not hot) fresh water for **5 minutes**.

- **Cleaning severely fouled sensors (visible deposits or marine growths on sensor)**: Soak the sensor in de-ionized water overnight to loosen deposits. Repeat the *Routine Cleaning* procedure up to 5 times. Do **not** attempt to clean the optical window with high pressure flow or by wiping or touching the window.

- **Long-Term Storage (after field use)**: **Do not fill the sensor with water, Triton solution, or Bleach solution. Store dry.**
  - **If there is danger of freezing,** shake all excess water out of the sensor. If in the optional sensor mount, loop tubing from inlet to outlet, leaving the optical window dry.

Materials

- **Triton X-100 - 100%** Triton X-100 is included with every CTD shipment and may be ordered from Sea-Bird; dilute as directed above. Triton X-100 is Octyl Phenol Ethoxylate, a mild, non-ionic surfactant (detergent), and is manufactured by Avantor Performance Materials (see http://avantormaterials.com/commerce/product.aspx?id=2147509608). Other liquid detergents can probably be used, but scientific grades (with no colors, perfumes, glycerins, lotions, etc.) are required.
- **Bleach** - Bleach is a common household product used to whiten and disinfect laundry. Commercially available bleach is typically 4% - 7% (40,000 – 70,000 ppm) **sodium hypochlorite** (Na-O-Cl) solution that includes stabilizers. Some common commercial product names are Clorox (U.S.) and eau de Javel (French).Clean the Hydro-DO with a 500 - 1000 ppm solution of water and sodium hypochlorite. **Dilute** the concentrated household bleach to 50 to 1 (50 parts water to 1 part bleach) to produce the proper concentration to clean the oxygen sensor.
- **Water** – We recommend de-ionized (DI) water because it is reliably pure, but commercially distilled water or fresh clean tap water is also sufficient for all uses above. **On ships, fresh water can occasionally contain traces of oil and should not be used for rinsing, cleaning, or storing sensors, unless there is no alternative.**

Sensor Calibration

Note:
See *Appendix I: Functional Description* for details on the calibration equation.

Each Hydro-DO is calibrated individually in a temperature-controlled bath. Bath temperatures are varied at each of 4 oxygen values, providing a comprehensive 24-point calibration. Two reference sensors in each bath are standardized against Winkler titrations. Response time tests are conducted on each sensor, using gas. Salinity and pressure impacts on sensor response are each checked at two separate points

The Hydro-DO calibration coefficients are printed on the Calibration Certificate supplied with the sensor. These coefficients have also been stored in the Hydro-DO, allowing the Hydro-DO to directly output dissolved oxygen in ml/l. When used on a Sea-Bird CTD (SBE 19*plus* V2, HydroCAT), dissolved oxygen can be calculated in other units in post-processing.

The primary mechanism for calibration drift in optical oxygen sensors is the fouling of the optical window by chemical or biological deposits. Accordingly, the most important determinant of long-term sensor accuracy is the cleanliness of the window. We recommend that oxygen sensors be calibrated before and after deployment, but particularly when the sensor has been exposed to contamination by oil slicks or biological material.

Another important mechanism for oxygen sensor drift is photobleaching of the sensor film. Keep the Hydro-DO sensor film out of direct sunlight. Also, every sample that is taken illuminates the film with short wavelength light that eventually degrades the film. As a rule of thumb, re-calibration of the oxygen sensor is recommended after 300,000 to500,000 samples.

Section 6: Troubleshooting

This section reviews common problems in operating the Hydro-DO, and provides the most likely causes and solutions.

Problem 1: Unable to Communicate with Hydro-DO

Notes:
- You can use any terminal program to set up the Hydro-DO; set it to 8 data bits, no parity, 1 stop bit, and 9600 baud (default Hydro-DO baud rate). Instructions here are for using SeatermV2.
- See SeatermV2's Help files.

The S> prompt indicates that communications between the Hydro-DO and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by clicking *Connect* in the Communications menu in Seaterm232.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the Hydro-DO and computer for a loose connection.

Cause/Solution 2: The instrument type and/or its communication settings may not have been entered correctly in the terminal program. Verify the settings in the Serial Port Configuration dialog box (Communications menu -> *Configure*). The settings should match those on the instrument Configuration Sheet.

Cause/Solution 3: The I/O cable may not be the correct one.
- The I/O cable supplied with the Hydro-DO's optional sensor mount permits connection to standard 9-pin RS-232 interfaces. See *Dimensions and Connector* in *Section 2: Description of Hydro-DO* for the cable pinouts.

Problem 2: Unreasonable Data

The symptom of this problem is data that contains unreasonable values (for example, values that are outside the expected range of the data).

Cause/Solution 1: Data with unreasonable values may be caused by incorrect calibration coefficients in the Hydro-DO (if looking at data output in converted format). Verify the calibration coefficients in the Hydro-DO, using **GetCC**.

Cause/Solution 2 (HydroCATs only): A data file with unreasonable values for dissolved oxygen may be caused by incorrect calibration coefficients in the HydroCAT. Send **GetCC** to verify the oxygen calibration coefficients in the HydroCAT match the Hydro-DO Calibration Certificates. Note that calibration coefficients do not affect the raw data stored in HydroCAT memory.
- If you have not yet overwritten the memory with new data, you can correct the coefficients and then upload the data again.
- If you have overwritten the memory with new data, you can manually correct the coefficients in the .xmlcon configuration file (which is generated when you upload the data from memory), and then reprocess the data in SBE Data Processing's Data Conversion module.

Cause/Solution 3 (SeaCATs only): A data file with nonsense values may be caused by incorrect instrument configuration of the SeaCAT (SBE 19*plus* V2):

- Bad data may be caused by incorrect setup in the CTD. Send **GetCD** or **DS** *to the CTD* to verify the CTD setup (Hydro-DO is enabled for the RS-232 auxiliary sensor channel).
- Bad data may be caused by incorrect configuration in the instrument .xmlcon configuration file, and/or incorrect calibration coefficients in the instrument configuration file. Verify the settings in the configuration file.

Note:
Each SeaCAT CTD is shipped with a configuration file that matches the configuration of the instrument (number and type of auxiliary sensors, etc.) and includes the instrument calibration coefficients.

Glossary

HydroCAT – High-accuracy conductivity, temperature, and pressure recorder. The HydroCAT is also available with an integrated Optical Dissolved Oxygen sensor (Hydro-DO) integrated at the factory.

Hydro-DO – High-accuracy Optical Dissolved Oxygen Sensor.

PCB – Printed Circuit Board.

SBE Data Processing – Sea-Bird's Windows data processing software, which calculates and plots temperature, conductivity, and optional internally mounted pressure, data from auxiliary sensors, and derived variables such as salinity and sound velocity.

Scan – One data sample.

SeaCAT – High-accuracy conductivity, temperature, and pressure CTD recorder that can provide power for and obtain data from a number of auxiliary sensors.

Note:
All Sea-Bird software listed was designed to work with a computer running Windows XP service pack 2 or later, Windows Vista, or Windows 7.

Seasave V7 – Sea-Bird's Windows software used to acquire, convert, and display real-time or archived raw data.

Seasoft V2– Sea-Bird's complete Windows software package, which includes software for communication, real-time data acquisition, and data analysis and display. Seasoft V2 includes **SeatermV2**, **Seasave V7**, and **SBE Data Processing**.

SeatermV2 – Windows terminal program *launcher*. Depending on the instrument selected, it launches Seaterm232 (RS-232 instruments), Seaterm485 (RS-485 instruments), SeatermIM (inductive modem instruments), or SeatermUSB (USB instruments).

Seaterm232 – Windows terminal program used with Sea-Bird instruments that communicate via an RS-232 interface, and that were developed or redesigned in 2006 and later. The common feature of these instruments is the ability to output data in XML.

Triton X-100 – Reagent grade non-ionic surfactant (detergent), used for cleaning the conductivity cell. Triton can be ordered from Sea-Bird, but should also be available locally from chemical supply or laboratory products companies. Triton is manufactured by Avantor Performance Materials (www.avantormaterials.com/commerce/product.aspx?id=2147509608).

Appendix I: Functional Description

Note:
Sea-Bird software performs these calculations automatically. This information is included for users who are developing their own software.

Note:
Calibration sheets generated after July 2012 include information on the conversion between phase delay in µsec and volts. Although this information was not shown on earlier calibration sheets, the same conversion is applicable:
- Divide the phase delay output (µsec) by 39.457071 to get output in volts, and use the output in volts in the calibration equation.

The Hydro-DO's luminescence decay time decreases non-linearly with increasing oxygen concentration. Because the phase delay between excited and emitted signals is shifted as a function of the ambient oxygen concentration, the phase delay is detected instead of the decay time. The signal is characterized by a modified Stern-Volmer equation as follows:

$$\mathbf{O_2\ (ml/L) = [(a_0 + a_1T + a_2V^2) / (b_0 + b_1V) - 1] / K_{sv}] [S_{Corr}] [P_{Corr}]}$$

where
- O_2 is oxygen concentration (ml/L)
- T is temperature output from Hydro-DO's thermistor in °C
- V is raw measured phase delay in volts = φ_r / 39.457071 (see Note)
- φ_r is raw measured phase delay in µsec (output when **SetFormat=1**)
- a_0, a_1, a_2, b_0, b_1 are calibration coefficients (Uchida et al, 2008)
- K_{sv} is Stern-Volmer constant (with calibration coefficients c_0, c_1, c_2) (Demas et al, 1999)
- S_{Corr} is salinity correction function (with calibration coefficients Sol_{B0}, Sol_{B1}, Sol_{B2}, Sol_{B3}, Sol_{C0})
- P_{Corr} is pressure correction function (with calibration coefficient E)

The Stern-Volmer constant equation is:

$$\mathbf{K_{sv} = c_0 + c_1T + c_2T^2}$$

where
- c_0, c_1, c_2 are calibration coefficients
- T is temperature output from Hydro-DO's thermistor in °C

The salinity correction equation is:

$$\mathbf{S_{Corr} = exp\ [S * (Sol_{B0} + Sol_{B1} * T_s + Sol_{B2} * T_s^2 + Sol_{B3} * T_s^3) + Sol_{C0} * S^2]}$$

where
- Salinity correction coefficients are constants (Benson and Krause, 1984) -
  $Sol_{B0} = -6.24523e^{-3}$
  $Sol_{B1} = -7.37614e^{-3}$
  $Sol_{B2} = -1.03410e^{-2}$
  $Sol_{B3} = -8.17083e^{-3}$
  $Sol_{C0} = -4.88682e^{-7}$
- $T_s = \ln [(298.15 - T) / (273.15 + T)]$
  where T is temperature output from Hydro-DO's thermistor in °C
- S = salinity
  - For oxygen in ml/l output directly from Hydro-DO, **SetRefSal=** is used as the salinity value in the salinity correction equation.
  - When the Hydro-DO is integrated with a CTD (SeaCAT or HydroCAT), **salinity calculated from the CTD data** should be used to calculate converted oxygen (ml/L, mg/L, etc.).
    - SeaCAT CTDs output raw phase delay and temperature from an integrated Hydro-DO. Sea-Bird software automatically uses the salinity from the CTD data if calculating converted oxygen output in Seasave real-time data acquisition software or SBE Data Processing post-processing software.
    - HydroCAT CTDs can output raw phase delay and temperature **or** converted oxygen in ml/L from an integrated Hydro-DO, depending on the user-selected output format in the HydroCAT. For converted oxygen in ml/L, the HydroCAT firmware automatically uses the salinity from the CTD data. Sea-Bird software automatically uses the salinity from the CTD data if calculating converted oxygen output in SBE Data Processing post-processing software.

The pressure correction equation is:
Pcorr = exp (E * P / K)
where

- Pressure correction coefficient is constant -
  E = 0.011
- K = temperature in Kelvin = T + 273.15
  where T is temperature output from Hydro-DO's thermistor in °C
- P = pressure (dbar) from CTD data
  - For oxygen in ml/l output directly from the Hydro-DO, **SetRefP=** is used as the pressure value in the pressure correction equation.
  - When the Hydro-DO is integrated with a CTD (SeaCAT or HydroCAT), **pressure calculated from the CTD data** should be used to calculate converted oxygen (ml/L, mg/L, etc.).
    - SeaCAT CTDs output raw phase delay and temperature from an integrated Hydro-DO. Sea-Bird software automatically uses the pressure from the CTD data if calculating converted oxygen output in Seasave real-time data acquisition software or SBE Data Processing post-processing software.
    - HydroCAT CTDs can output raw phase delay and temperature **or** converted oxygen in ml/L from an integrated Hydro-DO, depending on the user-selected output format in the HydroCAT. For converted oxygen in ml/L, the HydroCAT firmware automatically uses the pressure from the CTD data. Sea-Bird software automatically uses the pressure from the CTD data if calculating converted oxygen output in SBE Data Processing post-processing software.

Sea-Bird provides two calibration sheets with each Hydro-DO –

- One relates the Hydro-DO oxygen sensor output to oxygen concentration in ml/L – with coefficients a_0, a_1, a_2, b_0, b_1, c_0, c_1, c_2, and E.
- One relates the Hydro-DO thermistor output to temperature (°C) – with coefficients t_{a0}, t_{a1}, t_{a2}, t_{a3}

Examples of both calibration sheets are shown on the next two pages.

Example Calibration Sheet – Hydro-DO Oxygen Output (Phase Delay µsec)

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 14-Sep-12

SBE 63 OXYGEN CALIBRATION DATA

COEFFICIENTS

A0 = 1.0513e+000	B0 = -2.4323e-001	C0 = 1.0912e-001	E = 1.1000e-002
A1 = -1.5000e-003	B1 = 1.6036e+000	C1 = 4.6500e-003	
A2 = 3.7483e-001		C2 = 6.2813e-005	

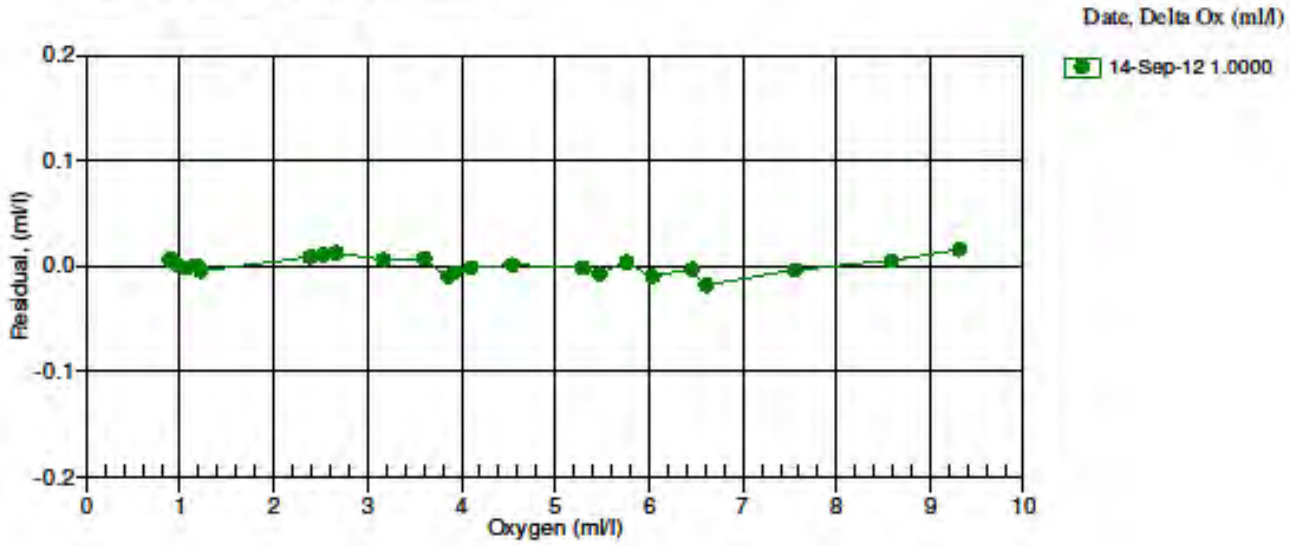
BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(U)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
0.888	30.00	0.00	29.48	0.895	0.007
0.921	26.00	0.00	30.19	0.925	0.004
0.970	20.00	0.00	31.34	0.971	0.001
1.063	12.00	0.00	32.84	1.061	-0.002
1.169	6.00	0.00	33.89	1.170	0.000
1.223	2.00	0.00	34.78	1.219	-0.005
2.387	30.00	0.00	21.94	2.395	0.008
2.528	26.00	0.00	22.48	2.539	0.011
2.664	20.00	0.00	23.68	2.676	0.013
3.167	12.00	0.00	24.69	3.174	0.006
3.603	6.00	0.00	25.64	3.610	0.007
3.855	30.00	0.00	18.29	3.845	-0.010
3.924	2.00	0.00	26.41	3.918	-0.006
4.107	26.00	0.00	18.72	4.105	-0.002
4.542	20.00	0.00	19.45	4.543	0.001
5.288	12.00	0.00	20.53	5.287	-0.002
5.471	26.00	0.00	16.65	5.464	-0.008
5.761	30.00	0.00	15.47	5.764	0.003
6.036	6.00	0.00	21.40	6.026	-0.010
6.454	20.00	0.00	16.86	6.450	-0.003
6.608	2.00	0.00	22.08	6.590	-0.018
7.555	12.00	0.00	17.78	7.551	-0.004
8.582	6.00	0.00	18.60	8.588	0.005
9.309	2.01	0.00	19.27	9.324	0.015

$V = U / 39.457071$

$Oxygen\ (ml/l) = \{((A0 + A1*T + A2 * V^2)/(B0 + B1 * V) - 1.0)/(C0 + C1 * T + C2 * T^2)\} * \exp(E * P / K)$

T = temperature [deg C], K = temperature [Kelvin], P = pressure [dbar]

Residual = instrument oxygen - bath oxygen



Example Calibration Sheet – Hydro-DO Temperature Output

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 14-Sep-12

SBE 63 OXYGEN CALIBRATION DATA

COEFFICIENTS

TA0 = 6.711077e-004 TA2 = 8.228029e-007
TA1 = 2.480232e-004 TA3 = 9.213712e-008

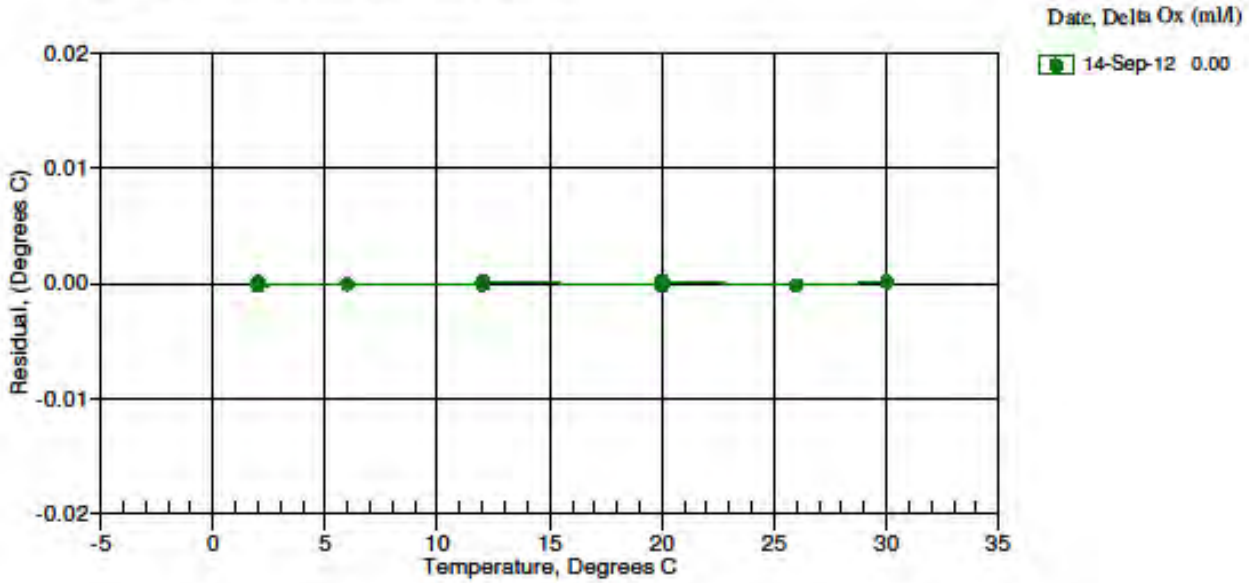
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
2.0000	1.26912	2.0001	0.00014
2.0000	1.26912	2.0001	0.00014
2.0001	1.26912	2.0001	0.00004
2.0108	1.26876	2.0106	-0.00020
6.0000	1.13620	5.9999	-0.00005
6.0000	1.13620	5.9999	-0.00005
6.0000	1.13620	5.9999	-0.00005
6.0000	1.13620	5.9999	-0.00005
11.9999	0.95559	11.9999	-0.00001
11.9999	0.95559	11.9999	-0.00001
12.0000	0.95559	11.9999	-0.00011
12.0001	0.95558	12.0003	0.00015
19.9999	0.75137	20.0002	0.00026
19.9999	0.75138	19.9997	-0.00018
20.0000	0.75137	20.0002	0.00016
20.0000	0.75137	20.0002	0.00016
26.0000	0.62467	25.9999	-0.00015
26.0000	0.62467	25.9999	-0.00015
26.0000	0.62467	25.9999	-0.00015
26.0000	0.62467	25.9999	-0.00015
30.0000	0.55173	30.0001	0.00009
30.0000	0.55173	30.0001	0.00009
30.0000	0.55173	30.0001	0.00009

Temperature ITS-90 = $1 / (TA0 + TA1 * L + TA2 * L^2 + TA3 * L^3) - 273.15$ (°C)

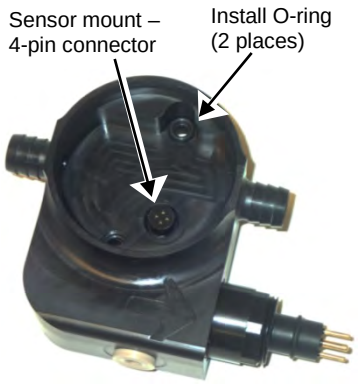
$L = ln\ (100000 * V / (3.3 - V))$

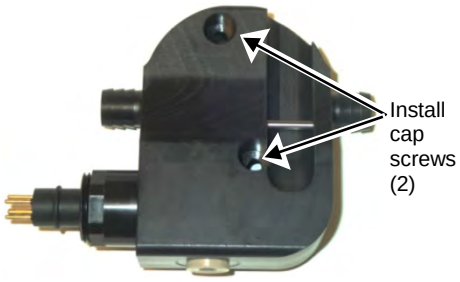
V = thermistor voltage

Residual = instrument temperature - bath temperature



Appendix II: Installation/Removal from Optional Sensor Mount





Installation

1. Place the two small O-rings on the sensor mount screw holes.
2. Align the 4-pin connectors and push the Hydro-DO onto the mount.
3. Install the two #10-24, 1/2” titanium cap screws from the back of the sensor mount to secure the Hydro-DO in the mount.

Removal

1. Remove the two #10-24, 1/2” titanium cap screws from the back of the sensor mount that secure the Hydro-DO in the mount.
2. Pull the Hydro-DO straight out of the sensor mount. If it is difficult to remove:
   - Use a rubber glove to provide a better grip as you pull. **OR**
   - Insert **one** of the cap screws in the sensor mount, and thread it just one or two turns. Push the head of the screw with a driver; this will push against the housing and free the O-ring seal. Remove the cap screws, and then pull the Hydro-DO straight out of the sensor mount.

Appendix III: Command Summary

Category	Command	Description
Status	**GetSD**	Get and display Configuration Data.
	GetHD	Get and display Hardware Data.
	GetCC	Get and display Calibration Coefficients.
Setup	**SetBaud=x**	**x=** Baud rate (600, 1200, 2400, 4800, 9600, 14400, 19200, 38400, 56000, 57600, 115200). ***Default 9600***.
	SetEcho=x	**x=1**: Echo characters received from computer. ***Default***. **x=0**: Do not.
	SetFormat=x	**x=0**: Converted oxygen and temperature (with units). **x=1**: Raw phase delay and thermistor voltage, converted oxygen and temperature (no units), for compatibility with SeaCATs (19*plus* V2) and HydroCATs. ***Default***. **x=2**: Raw and converted data. **x=3**: Instrument name, serial number, and converted data.
	SetBootDelay =x	**x=** delay after power is applied before sampling (1 - 255 sec). ***Default 1***. Only applicable if **AutoRun=1**.
	SetInterval=x	**x**= interval (sec) between samples (1 – 32,767) for autonomous sampling. ***Default 4***.
	SetAvg=x	**x** = number of measurements to average per sample (1–64, or 1–32 for 1Hz sampling); each measurement takes approximately 0.0167 sec. Increasing **SetAvg=** may shorten sensor film life. ***Default 2***.
	SetAutoRun= x	**x=0**: Wait for command when power is applied. ***Default***. **x=1**: Begin sampling when power is applied. First sample is taken after **SetBootDelay=**.
	***Default**	Reset most Setup parameters to factory defaults. Note that baud (**SetBaud=**) is **not** reset.
Sampling	**Start** or **Go**	Start autonomous sampling at rate set by **SetInterval=**. To stop autonomous sampling, click Esc or send **Stop** (which then allows you to enter status or setup commands), or remove power.
	Stop	Stop autonomous sampling.
	TS	Take **1** sample, transmit data in format defined by **SetFormat=**.
	TSR	Take **1** sample, transmit data in raw format (for factory diagnostics).
Coefficients (F=floating point number; S=string with no spaces) Initially factory-set and should agree with Calibration Certificate shipped with Hydro-DO.	**SetCalDate=S**	**S=** calibration date (days since January 1, 2000).
	SetTA0=F	**F=** TA0 coefficient.
	SetTA1=F	**F=** TA1 coefficient.
	SetTA2=F	**F=** TA2 coefficient.
	SetTA3=F	**F=** TA3 coefficient.
	SetA0=F	**F=**A0 coefficient.
	SetA1=F	**F=**A1 coefficient.
	SetA2=F	**F=**A2 coefficient.
	SetB0=F	**F=** B0 coefficient.
	SetB1=F	**F=** B1 coefficient.
	SetC0=F	**F=**C0 coefficient.
	SetC1=F	**F=**C1 coefficient.
	SetC2=F	**F=**C2 coefficient.
	SetE=F	**F=** E coefficient.
	SetSolB0=F	**F=** SolB0 coefficient.
	SetSolB1=F	**F=** SolB1 coefficient.
	SetSolB2=F	**F=** SolB2 coefficient.
	SetSolB3=F	**F=** SolB3 coefficient.
	SetSolC0=F	**F=** SolC0 coefficient.
	SetRefSal=F	**F**=Reference salinity (psu) to use for oxygen calculation in converted units. Default 0. For moorings, enter approximate value expected for deployment. For profiling, enter 0, and correct for salinity in post-processing.
	SetRefP=F	**F**=Reference pressure (dbar) to use for oxygen calculation in converted units. Default 0. For moorings, enter approximate value expected for deployment. For profiling, enter 0, and correct for pressure in post-processing.

Appendix IV: Replacement Parts

Part Number	Part	Application Description	Quantity in Hydro-DO
802273	Sensor mount with standard (XSG) connector	For mounting on and integration with SBE 19*plus* V2	-
802274	Sensor mount with optional wet-pluggable (MCBH) connector	For mounting on and integration with SBE 19*plus* V2	-
311133	#10-24 cap screws, 1/2” length, titanium	Secure Hydro-DO in optional sensor mount	-
50510	Sensor mount kit with standard (XSG) connector	Kit includes sensor mount (802296), clamp, and tape; for mounting on and integration with SBE 19*plus* V2	-
50511	Sensor mount kit with optional wet-pluggable (MCBH) connector	Kit includes sensor mount (802297), clamp, and tape; for mounting on and integration with SBE 19*plus* V2	-
17088	Interface cable with standard (XSG) connectors	For integration with SBE 19*plus* V2	-
171792	Interface cable with optional wet-pluggable (MCBH) connectors	For integration with SBE 19*plus* V2	-
31450	Tygon tubing, 1/2" ID X 3/4" OD, 2 m, Black	Main plumbing for integration with SBE 19*plus* V2	-
90087	Universal plumbing kit	Includes air release valve, Y-fitting, and tubing for integration with SBE 19*plus* V2	-

Appendix V: Manual Revision History

Manual Version	Date	Description
007	12/13	• Initial production release of Hydro-DO

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